



Atmospheric stability and complex terrain - Comparing measurements and CFD

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Atmospheric stability and complex terrain

Comparing measurements and CFD

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A. Bechmann

J. Berg

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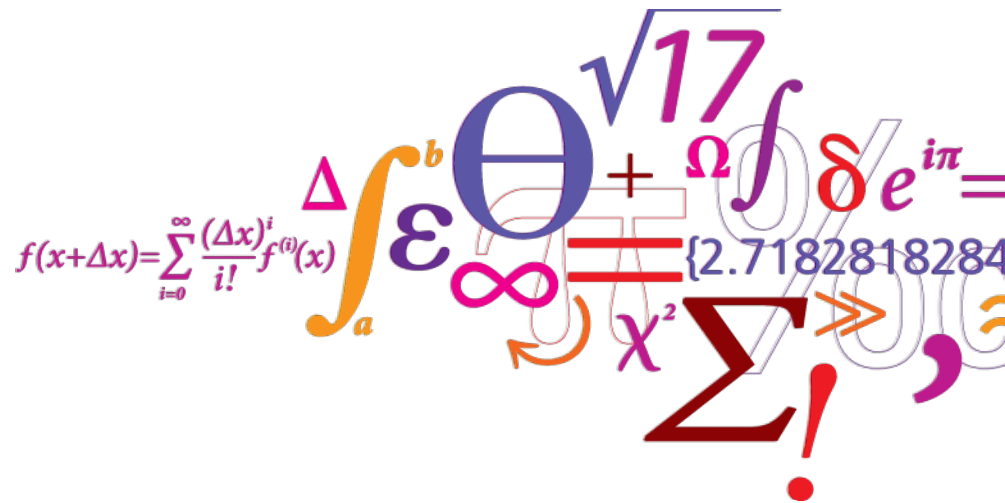
N. N. Sørensen

P.-E. Réthoré



DTU Wind Energy

Department of Wind Energy



Atmospheric stability

Chimney plume under stable and unstable conditions

stable



unstable

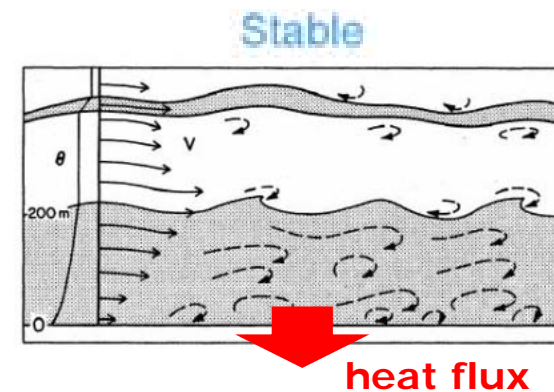
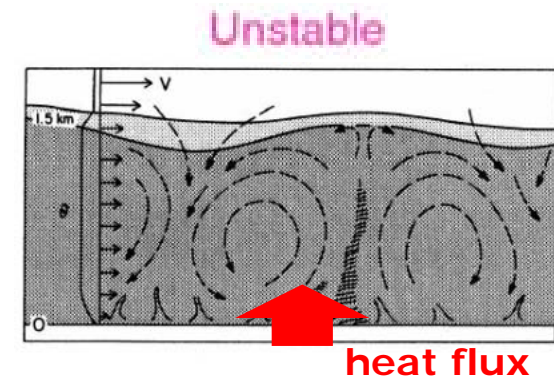
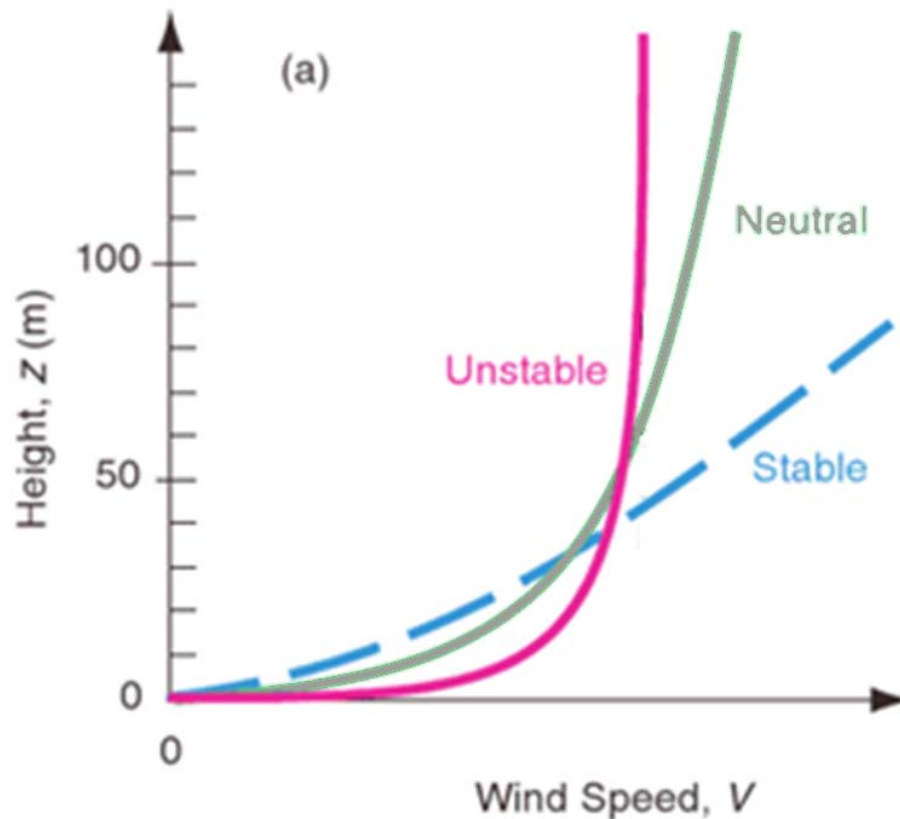


Source: kindly been provided by
Dr. Torben Mikkelsen, Risø DTU and
Dr. Thomas Ellermann,
National Environmental Research Institute

Atmospheric stability

Why: Influence on the wind field

Flat terrain

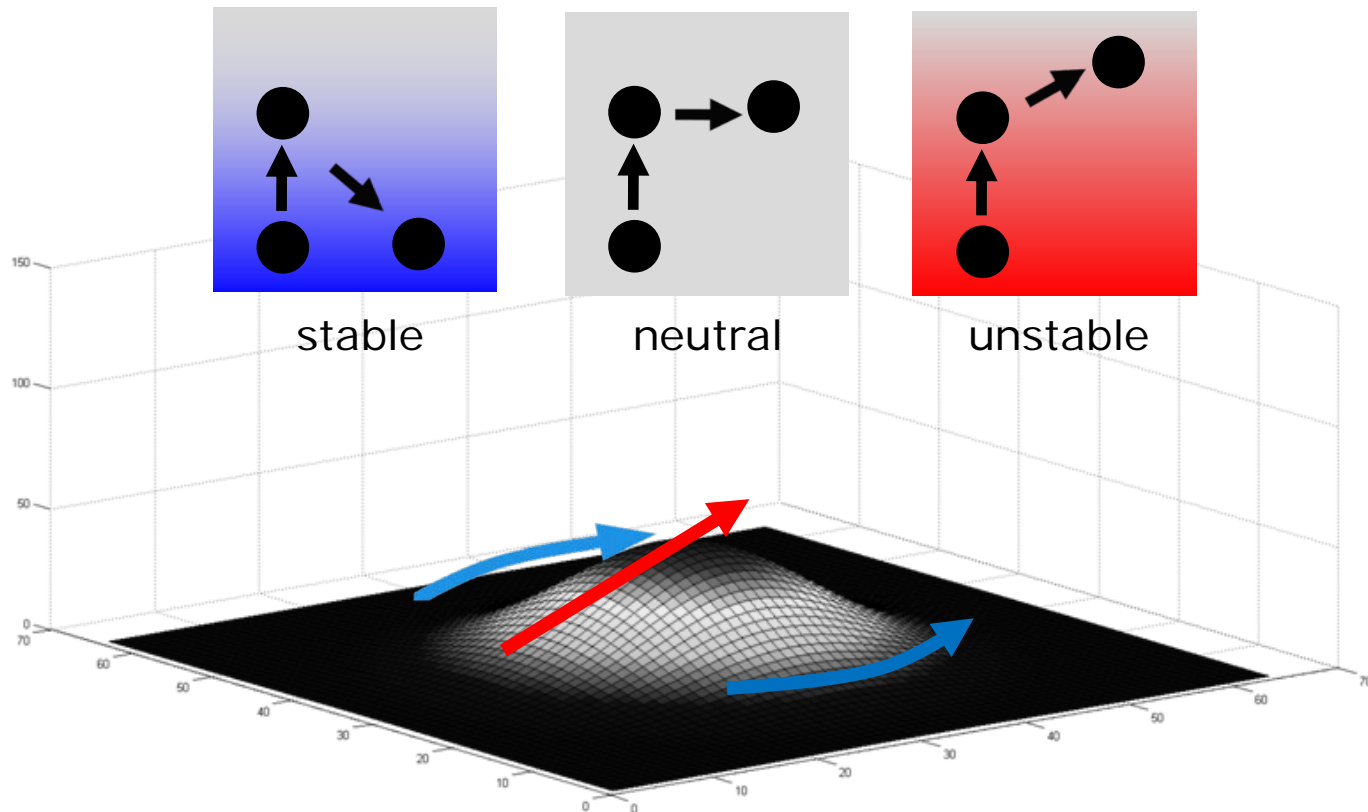


Source: Kaimal and Finnigan 1994,
Wallace and Hobbs 2006

Atmospheric stability

Why: Influence on the wind field

Complex terrain



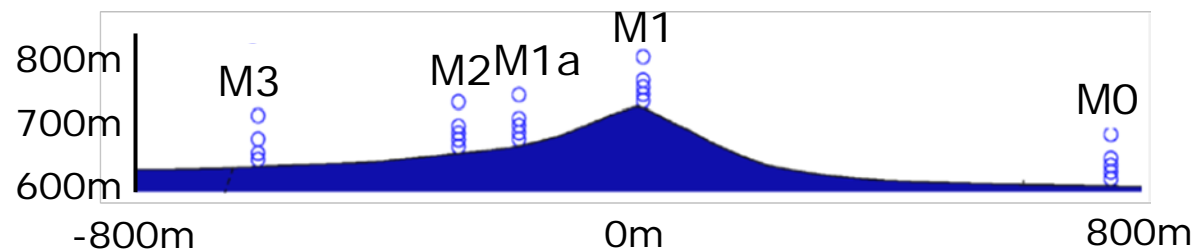
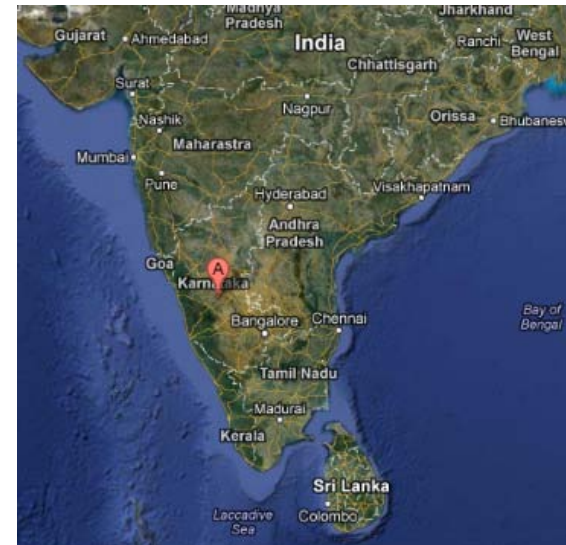
The Benakanahalli experiment

Stratification and Complex Terrain



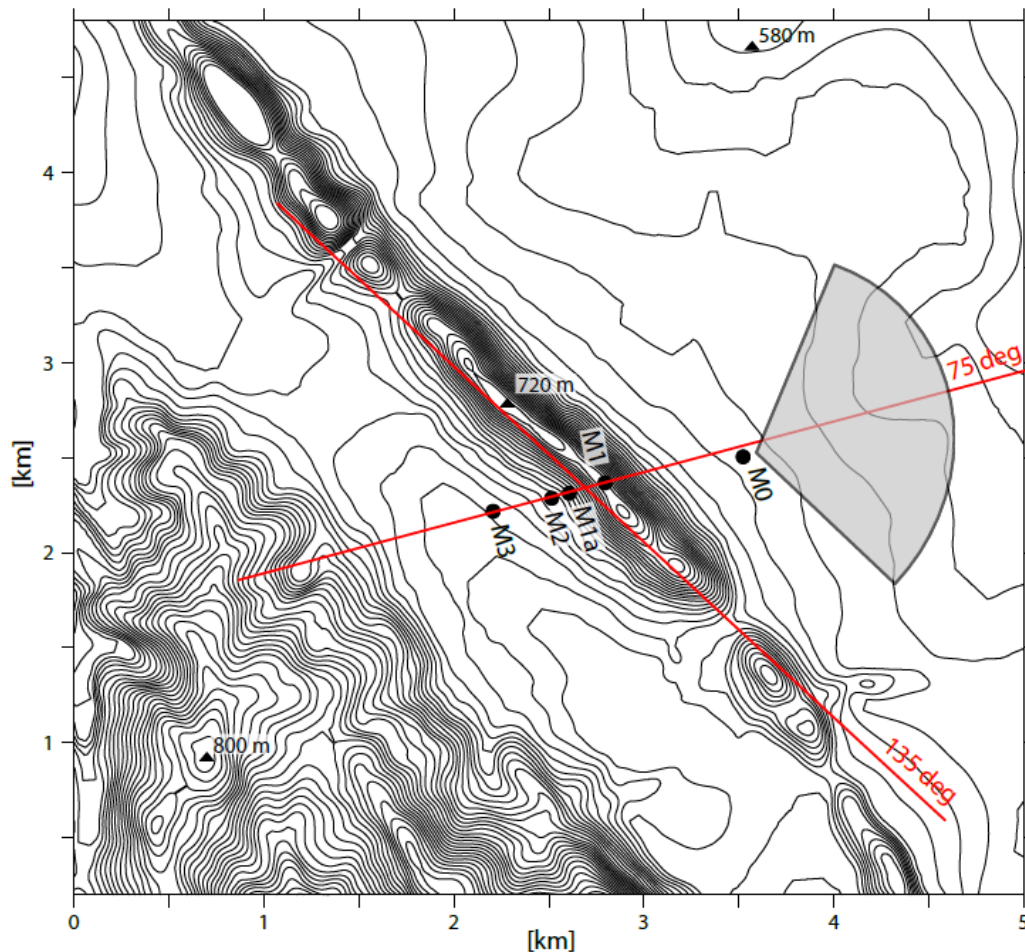
The Benakanahalli experiment

Location and instrumentation



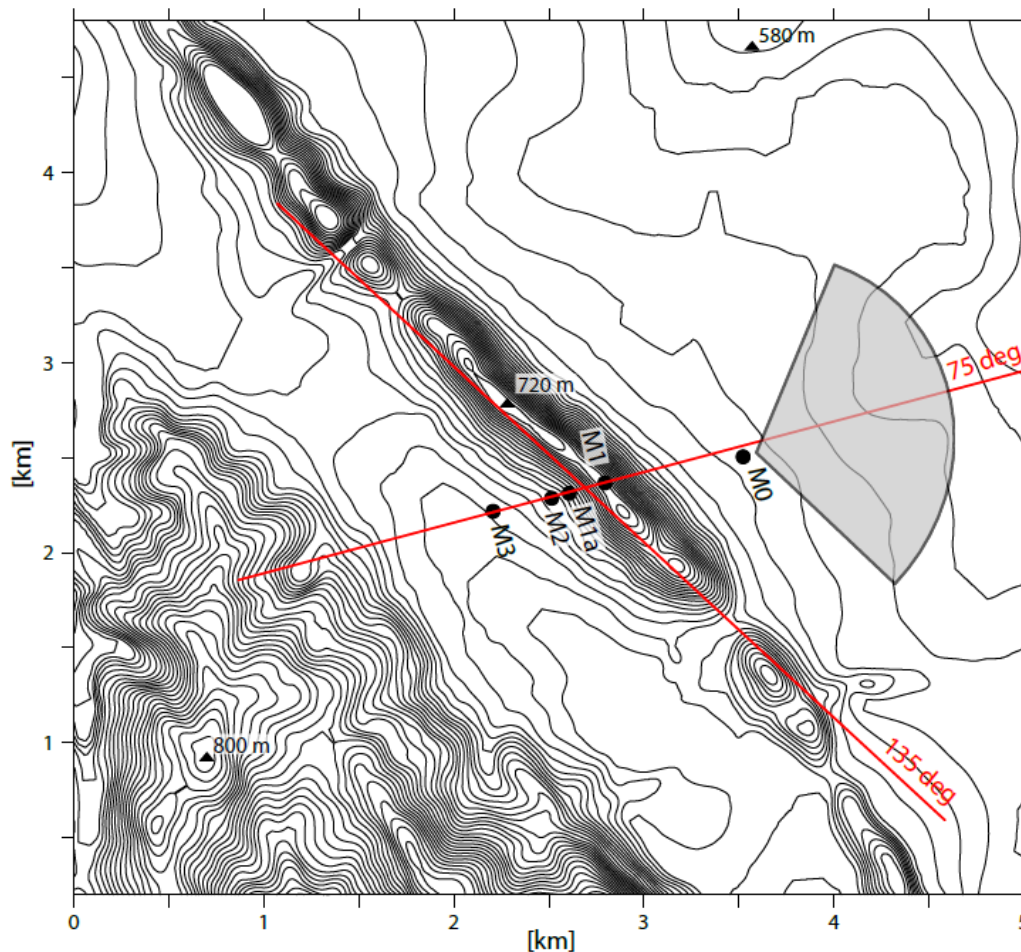
The Benakanahalli experiment

Location and instrumentation

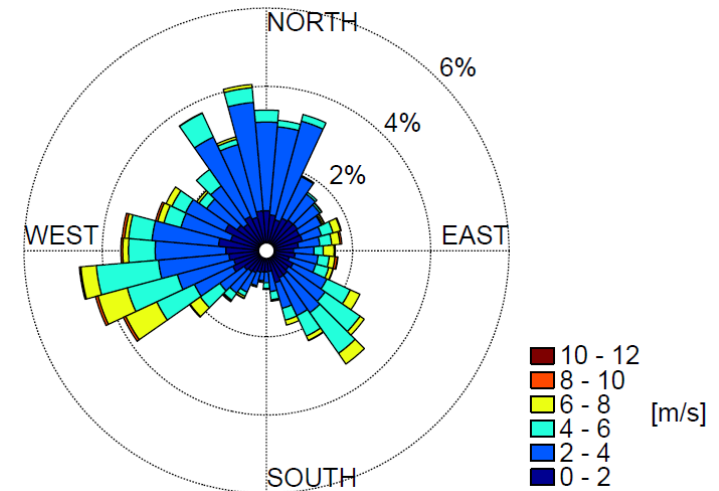


The Benakanahalli experiment

Wind climate

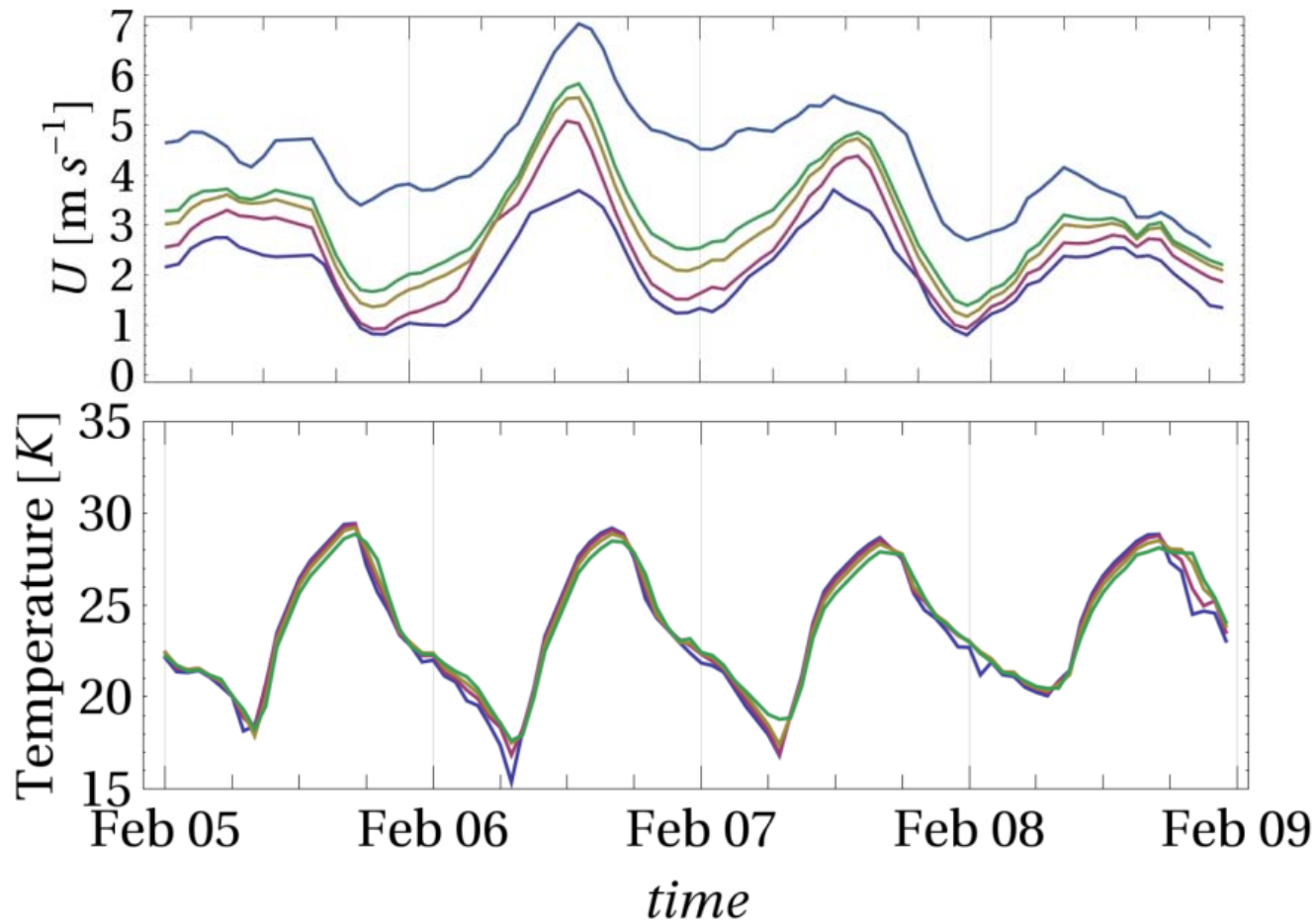


Wind rose at M0



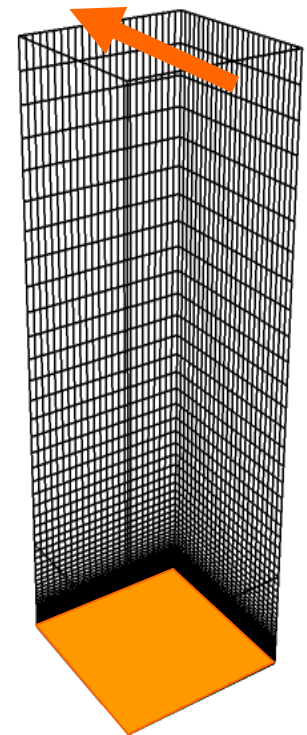
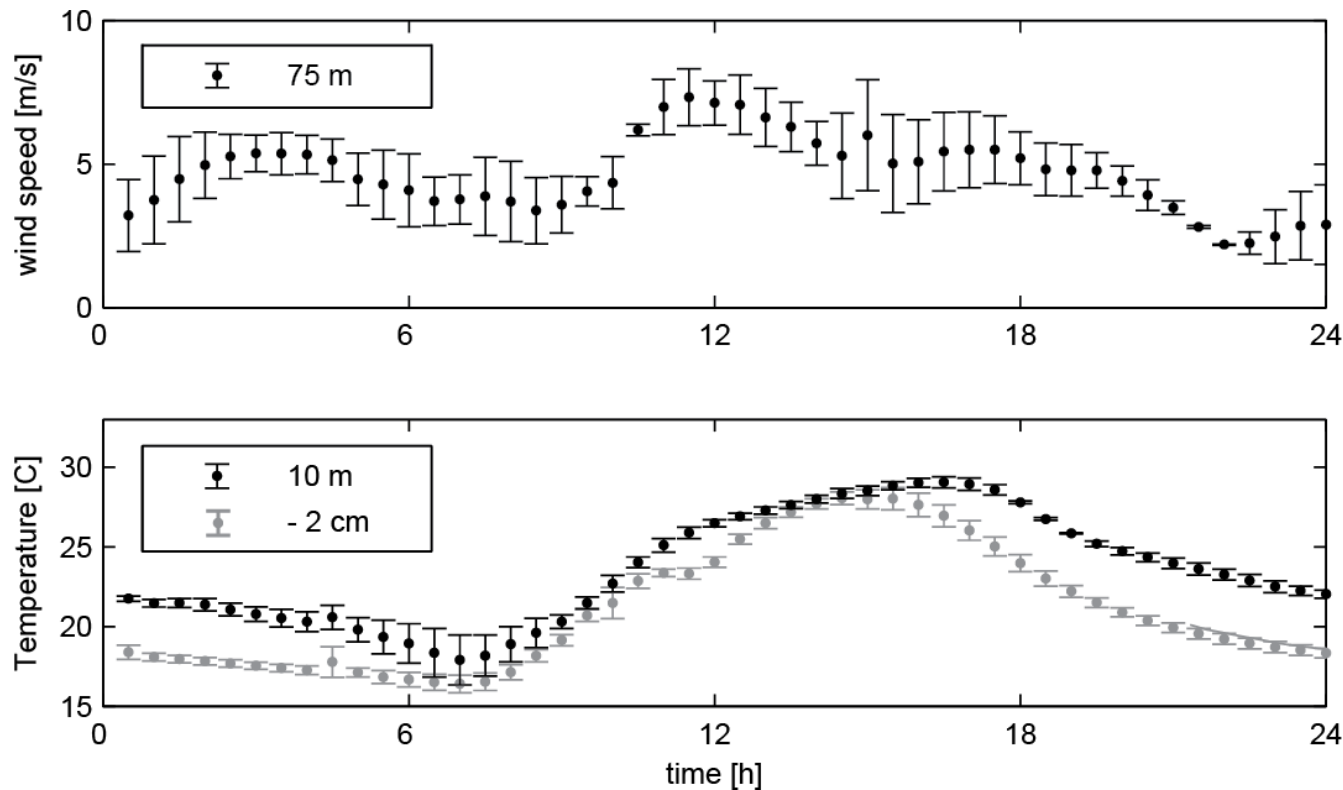
Benchmark dataset

Selected data: 3 days in February 2010



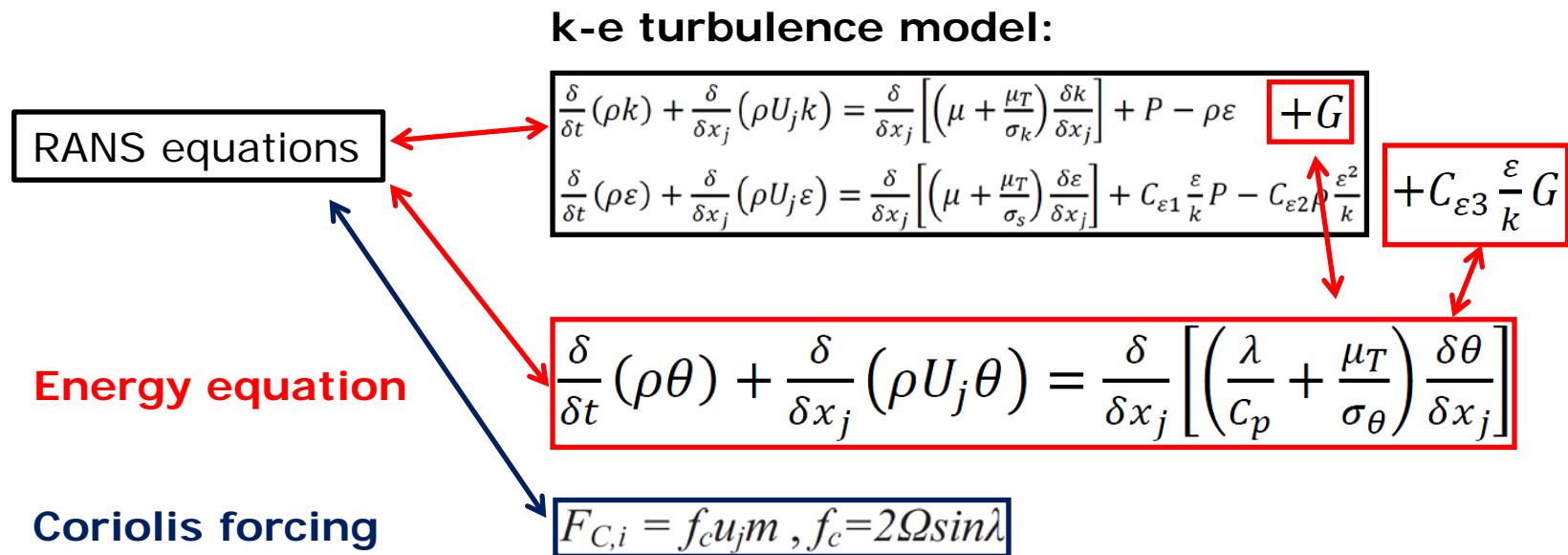
Benchmark dataset

Averaged data and model forcing



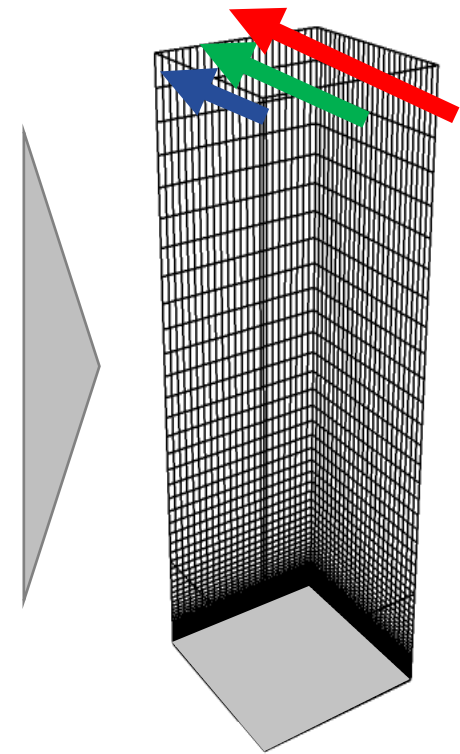
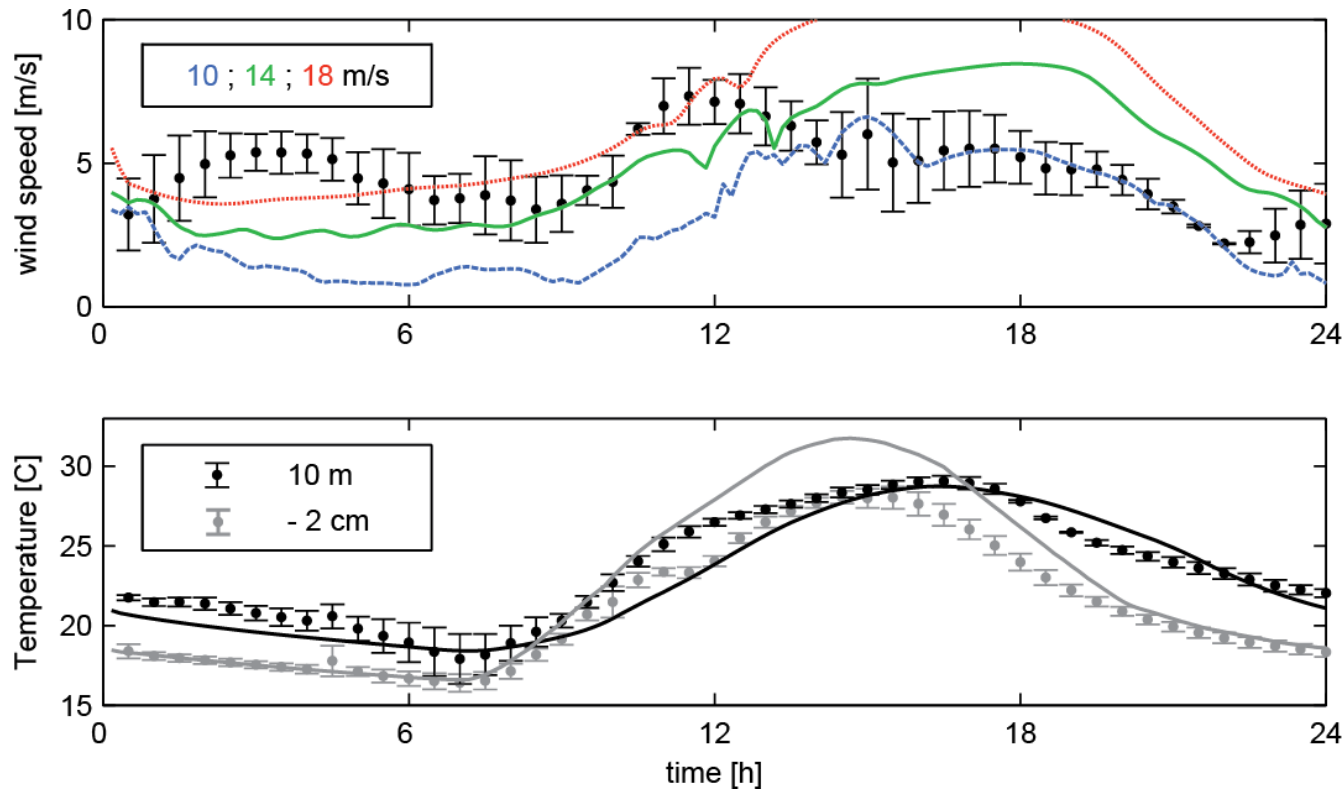
Simulating Benakanahalli

Modeling atmospheric stability in CFD



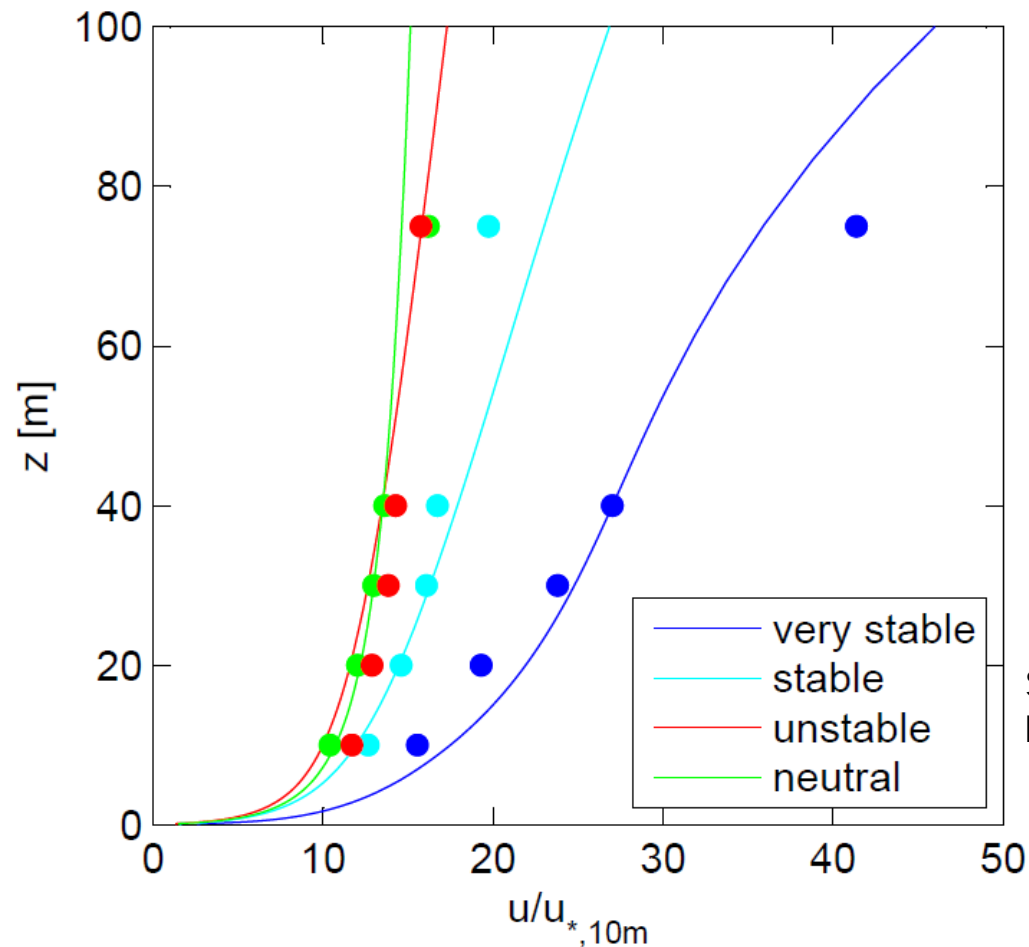
Simulating Benakanahalli

Precursor simulation vs. Measurements at M0



Simulating Benakanahalli

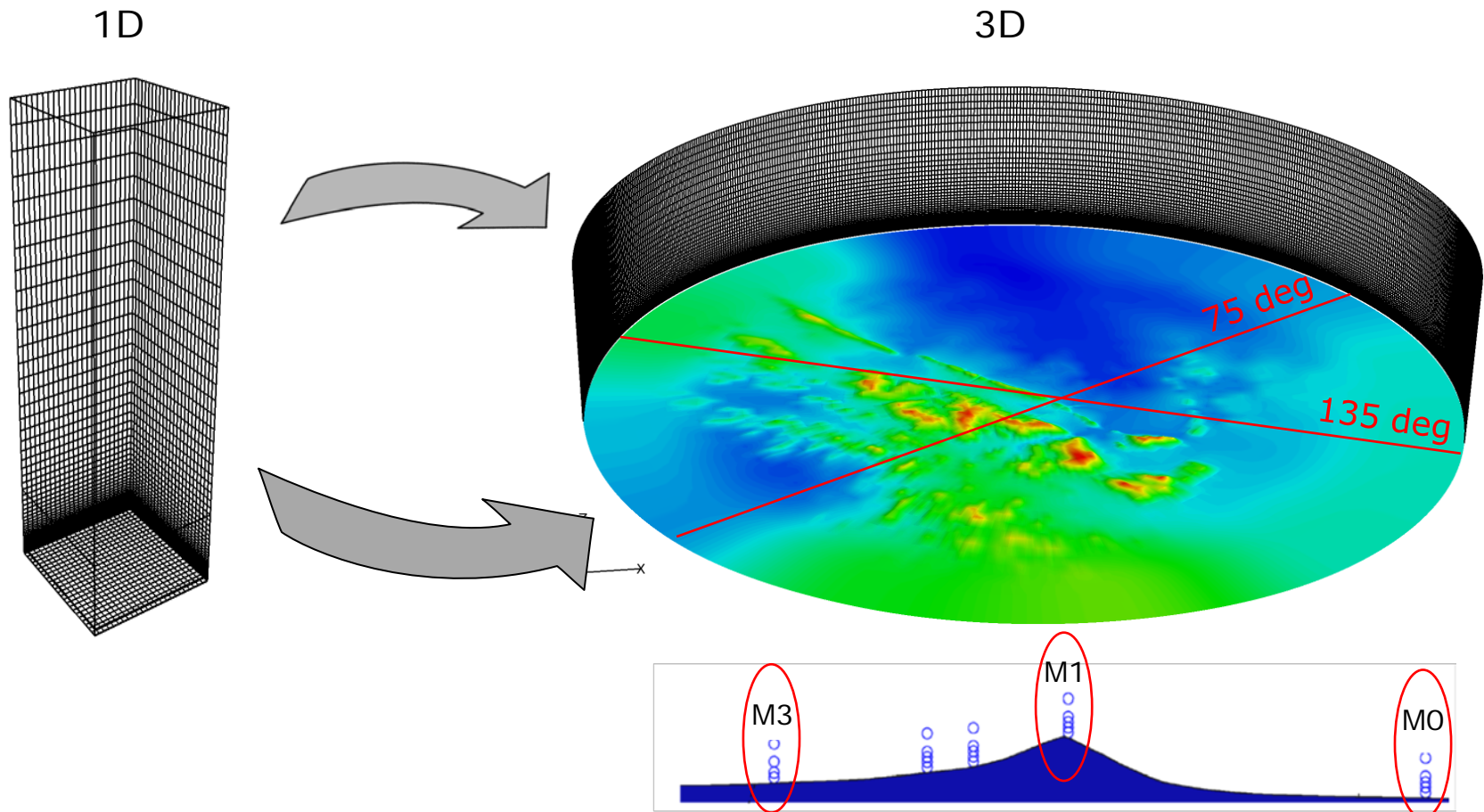
Precursor simulation vs. Measurements at M0



Stability classes based on Monin-Obukhov length

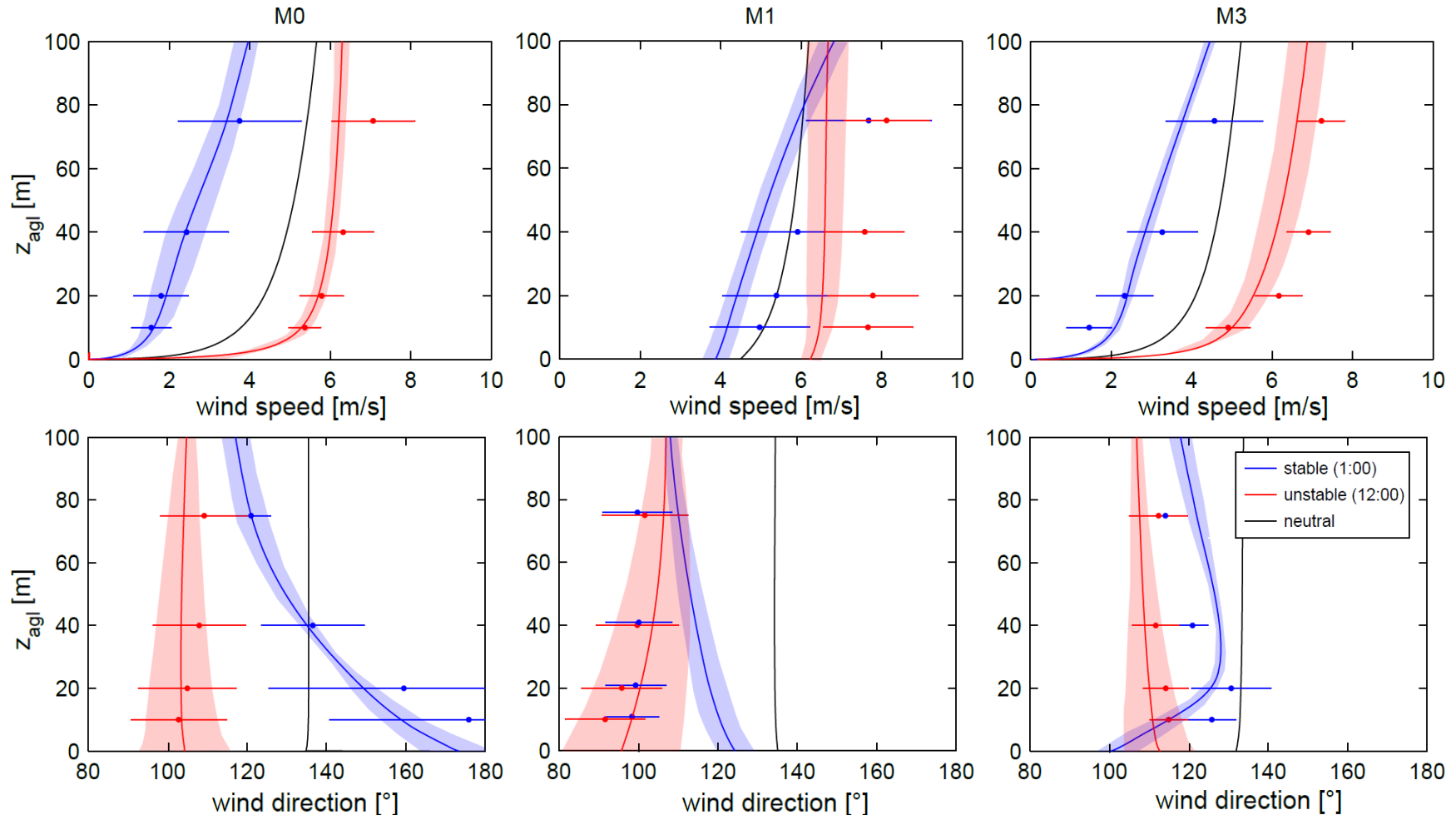
Simulating Benakanahalli

Computational mesh and boundary conditions



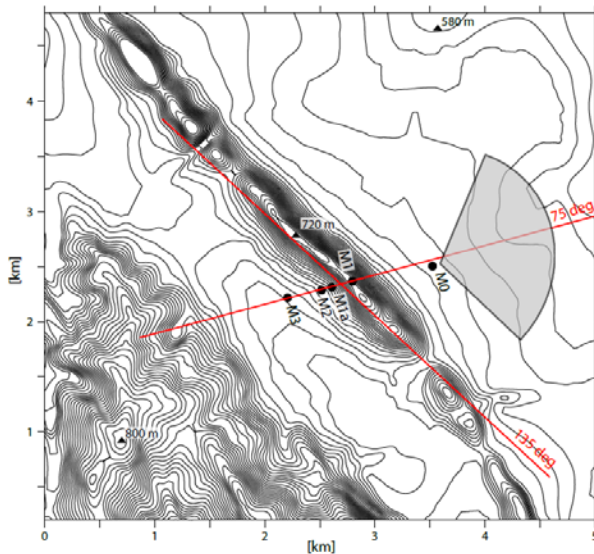
Simulating Benakanahalli

Wind speed and direction: comparison of modeled and observed data

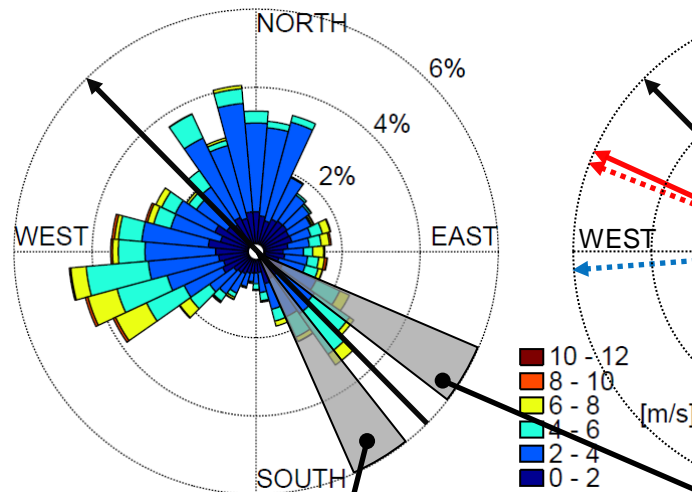


Simulating Benakanahalli

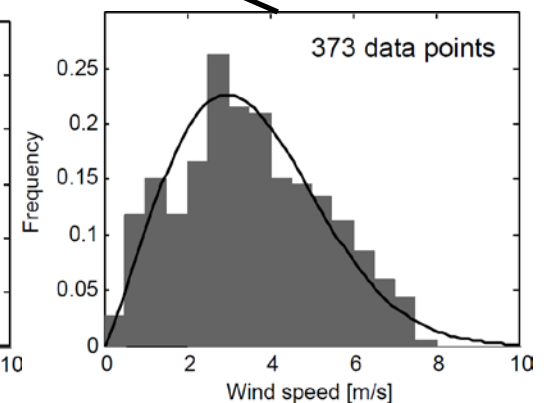
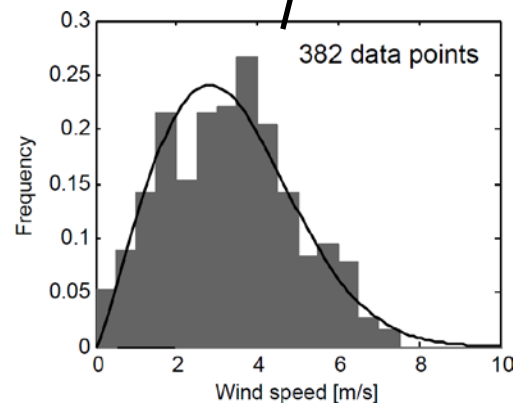
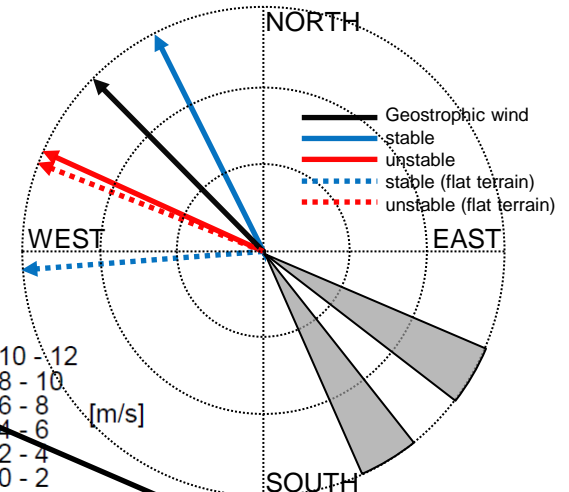
Contour map of terrain



Wind rose

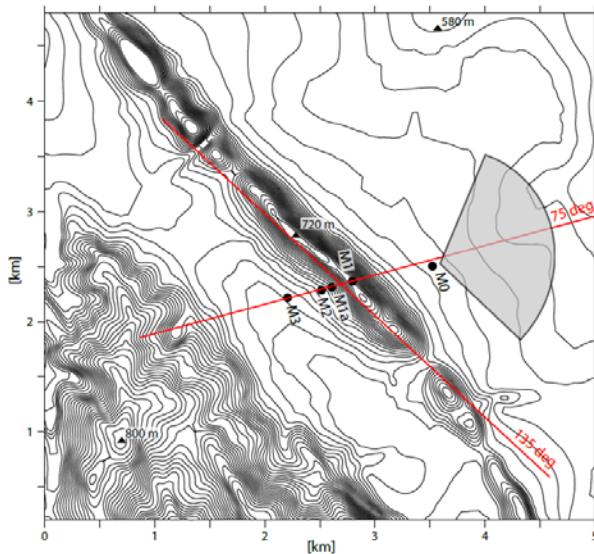


Wind direction in 20m

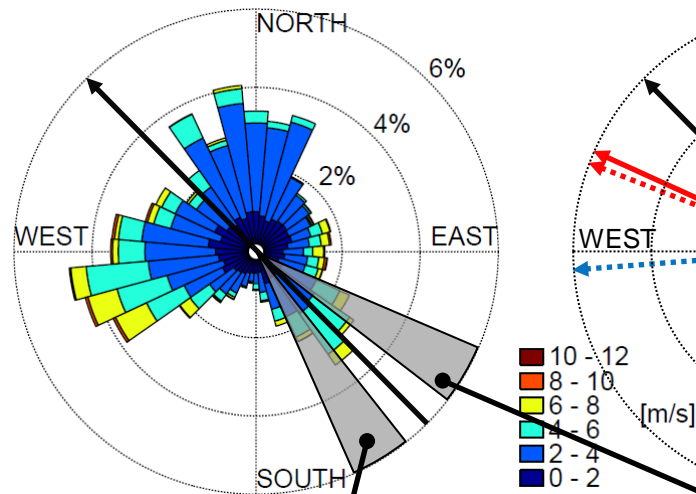


Simulating Benakanahalli

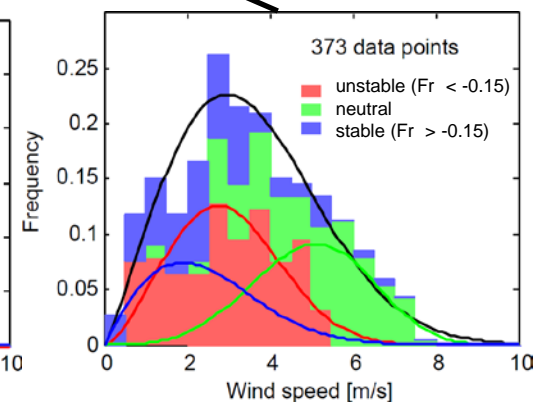
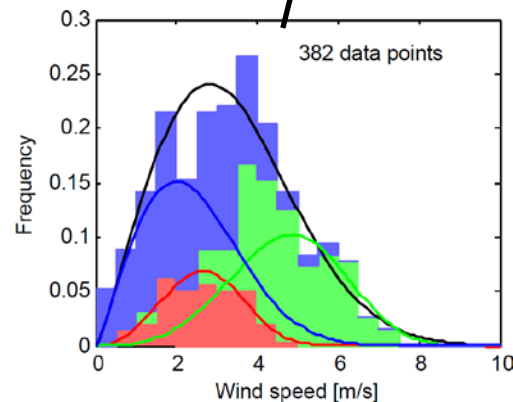
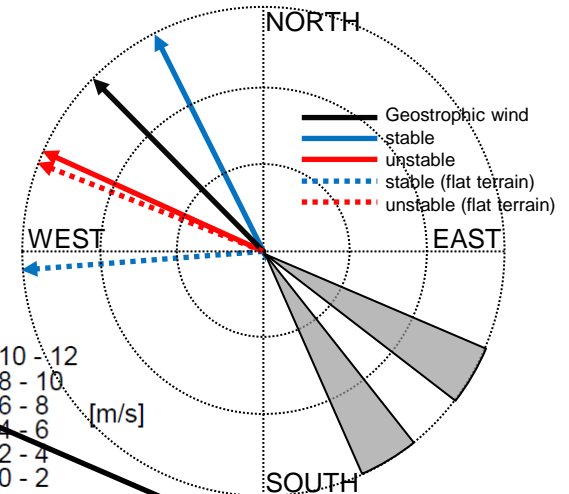
Contour map of terrain



Wind rose

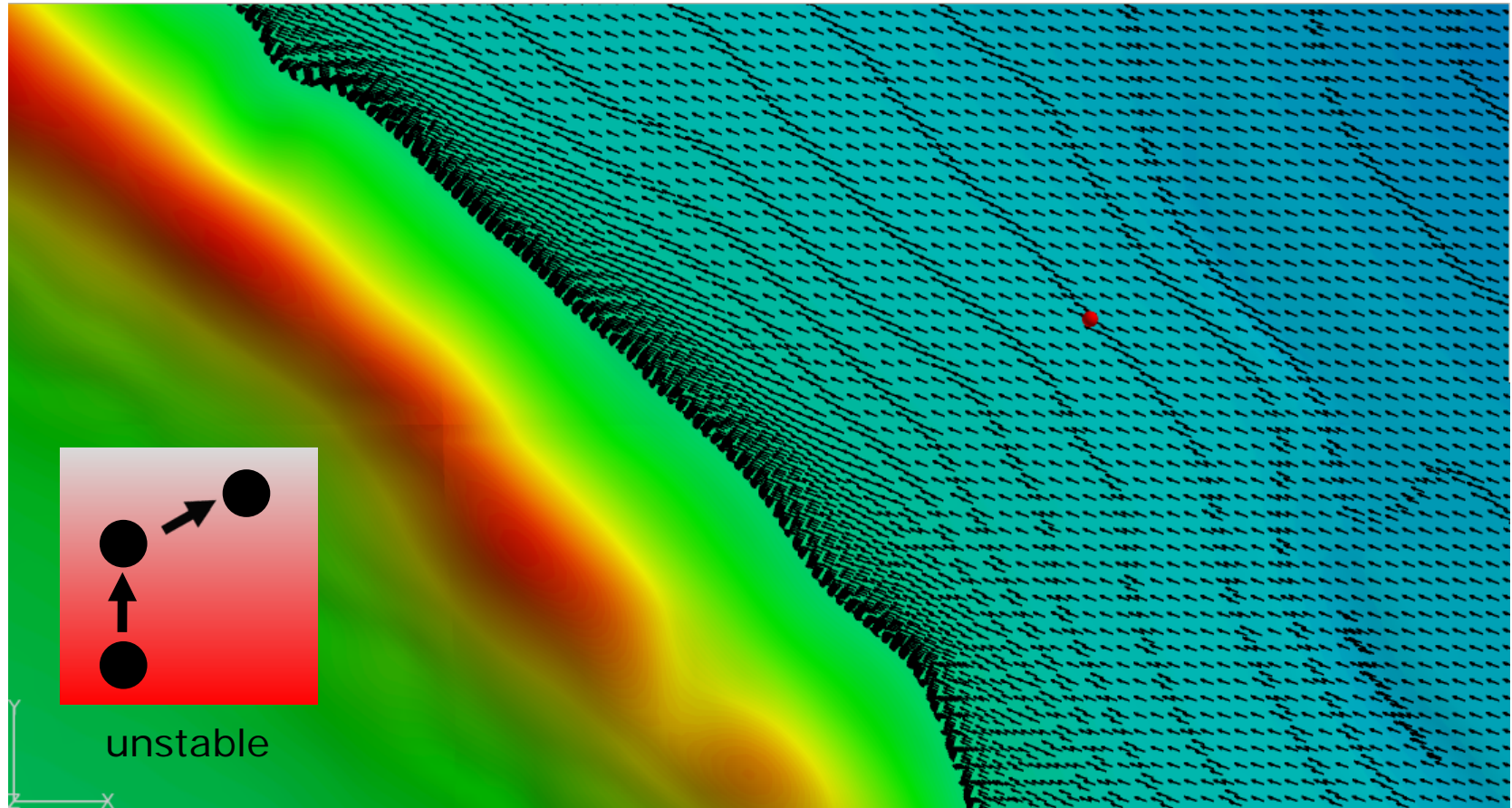


Wind direction in 20m



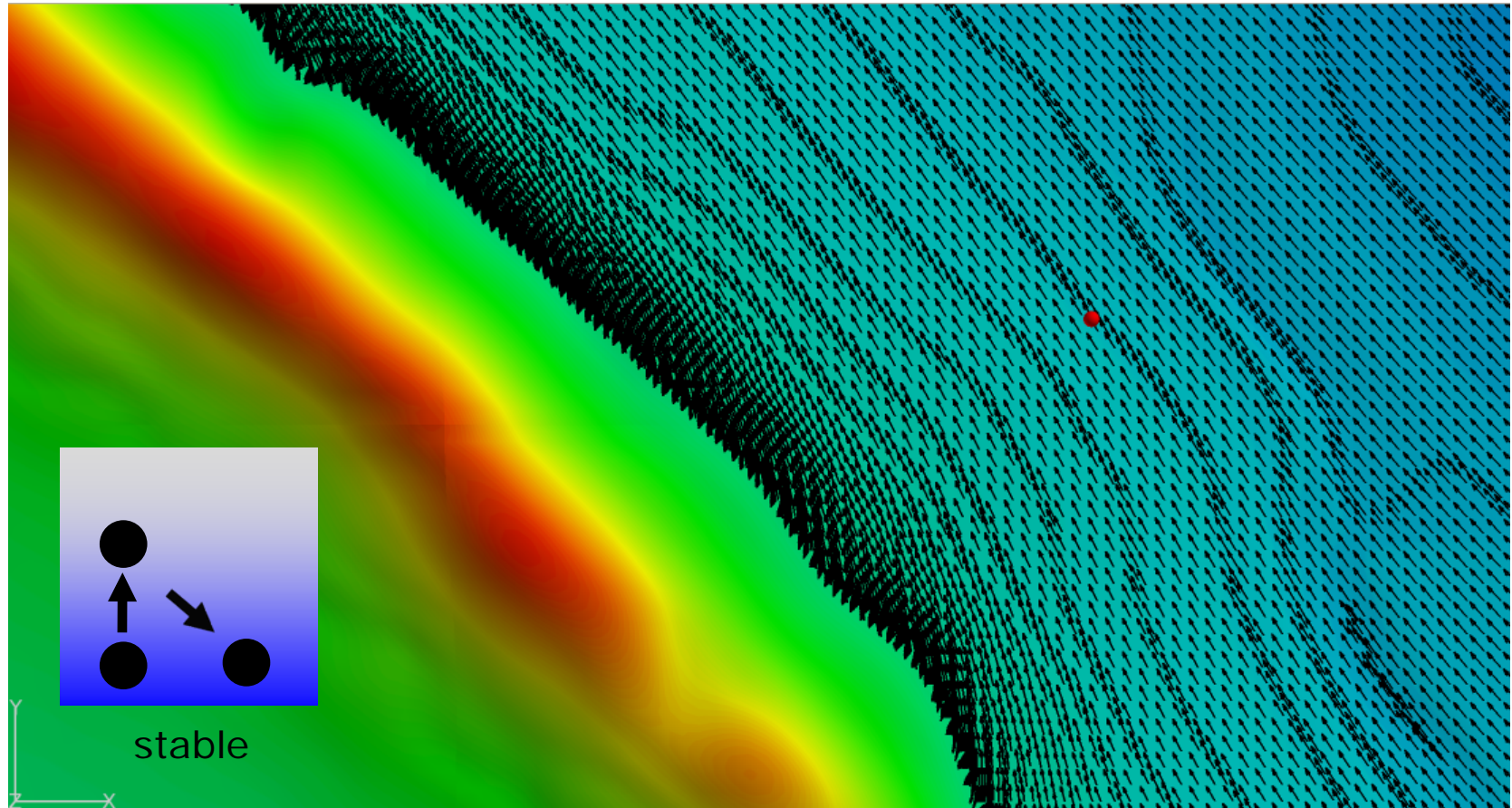
Simulating Benakanahalli

Unstable conditions: wind field at 12 p.m.



Simulating Benakanahalli

Stable conditions: wind field at 1 a.m.



Conlcusions & Future work

Conclusions:

- Stability effects and Coriolis force implemented in EllipSys3D
- Methodology is generally applicable
- Improvement in predicting the airflow over Benakanahalli during non-neutral conditions

Future work:

- Get more information about boundary and intial conditions
- Mesoscale simulations to provide information on large scales
- Generate roughness map to replace uniform roughness
- Different parameterizations in turbulence model

Simulating Benakanahalli

Terrain effects on M0

